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ABSTRACT

This pamphlet describes the preparations for launching a giant Atlas, Gemini (Titan 11), or Saturn launch vehicle. The material is intended for use in elementary general science. The pamphlet is one of the NASA Facts Science Series (each of which consists of four pages) and is designed to fit in the standard size three-ring notebook. Review questions, suggested activities, and references are included. (PR)

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The Countdown

Precise checks are maintained on all phases of the countdown by experts seated at television control panels such as this at the Mission Control Center. The countdown can be halted at any moment for as long as might be required to make a fix. If the fix is to require a longer time than is permissible in the flight schedule for that day the mission is cancelled. After the fix is made the mission is rescheduled and a new countdown begun.

The countdown from 10 to 0 immediately before a big space vehicle is launched has become a familiar and very exciting occurrence, thanks to television and radio. But this count measures only the last ten seconds before a launch; there is a "pre-count" starting as early as three days before launch, a "mid-count" starting about a day ahead and then a terminal count for the last few hours.

Preparations for launching a giant Atlas, Gemini (Titan II), or Saturn launch vehicle are very exacting and take a great deal of time. Every system, component and part in the vehicle must be checked thoroughly and declared ready so that proper function in space can be anticipated. If even just one tiny bolt isn't in place just as it should be, then the countdown is stopped until it *is* in place. Consequently, it is easy to see that the last few days and hours on the launch pad include a busy, constant schedule of final checks. This entire period of time is called the "countdown."

All times before launch are called "minus time," and those after are denoted as "plus time." Thus, "T minus 2 minutes" means that two minutes remain before launch; "T plus 9 seconds" means that launch occurred 9 seconds earlier. The minus countdown ends with "T-time" or zero time, when rocket engine ignition and lift-off occur. After T-time, the countdown continues into the plus count.

Keeping track of this vital span of time is by no means limited to operations at the launch pad.

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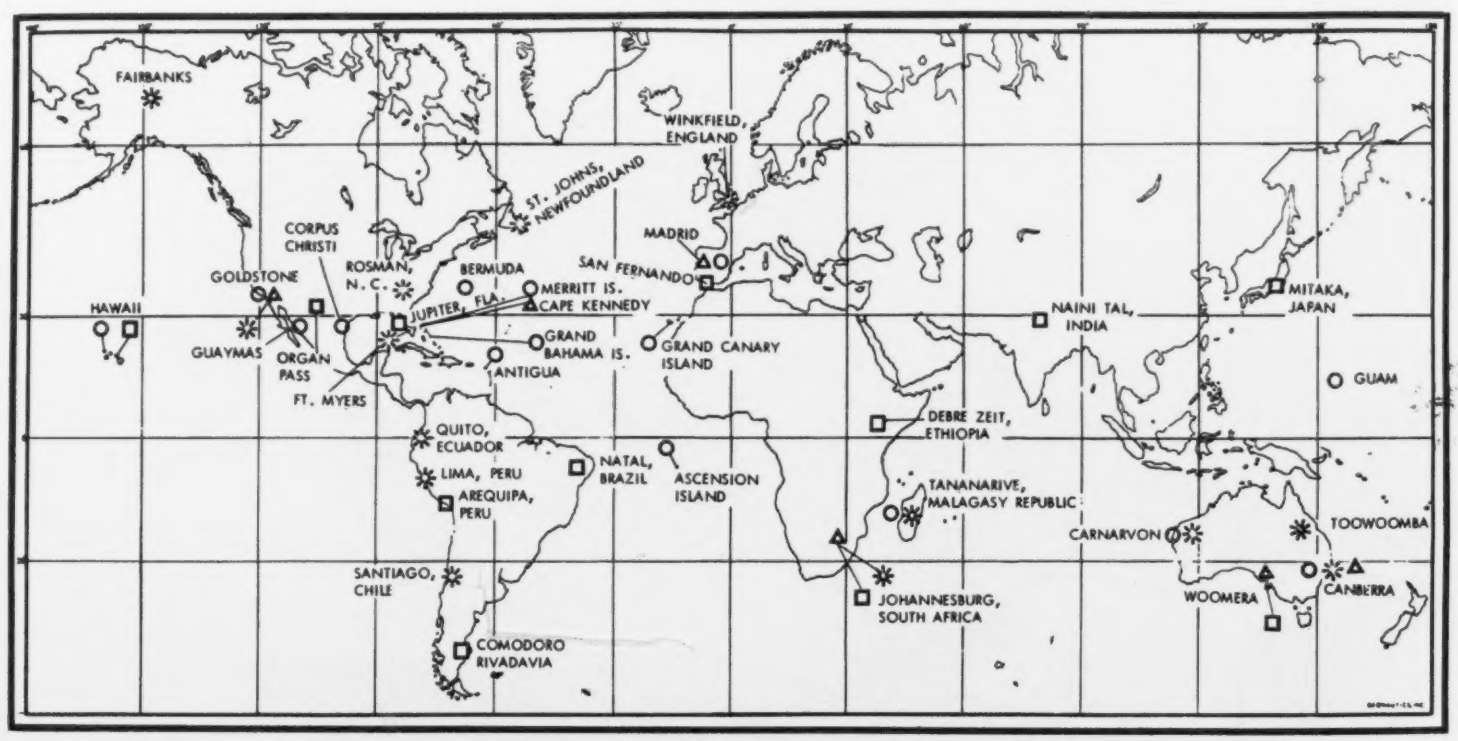

NASA TRACKING FACILITIES

○ MANNED SPACE FLIGHT NETWORK ✲ SATELLITE TRACKING AND DATA ACQUISITION NETWORK △ DEEP SPACE INSTRUMENTATION FACILITIES □ OPTICAL TRACKING NETWORK

This is a map of the entire tracking and communications network NASA uses to track sounding rockets, satellites, manned space flights and unmanned deep space missions. These stations are all located on land sites. In addition, for projects such as the Apollo lunar landing mission, numerous aircraft and ships will add air and sea area communications and tracking stations. These additional stations give NASA experts direct line-of-sight communications capabilities at all times.

Stations on the tracking network around the world are alerted well in advance and are kept notified of the exact count at all times. This is very important because the tracking stations must be tuned in and ready to report the position and communicate with the space vehicle as it passes on each revolution.

To assure mission success, every functioning part of the spacecraft and its launch vehicle must be synchronized—timed perfectly to operate in harmony with all other parts. There is a well planned, minute-by-minute written schedule of starting events for preparation of the rocket launching. During this period the many tiny motors and other devices are checked and switched on in turn. Therefore, the countdown is actually a "checkoff list" used so that launch operations may be performed with accuracy. Everything to be done is written down opposite a set time for that action.

At any time during the countdown, it is possible to introduce a delay or "hold." If a repair, adjustment, or replacement is needed in the spacecraft or the launch vehicle, or if there is a problem somewhere on the world-wide tracking network, the count is stopped for whatever time is needed for corrective action. For example, at T minus 2 hours, 6 minutes, an adjustment to the engine plumbing may be needed. If it is a major adjustment indicating an hour or more for repair, the countdown will be stopped at that minute. Later, when repairs are complete, the countdown continues or "resumes," beginning at T minus 2 hours, 6 minutes. In case

the delay causes a necessary rechecking of other operations already performed, the countdown may be "recycled," or turned back to allow more test time before launch. For example, the countdown may be reset to say, T minus 2 hours, 36 minutes.

During the last minute the countdown is read off in seconds. This last minute includes a large number of starting functions not only in the rocket but also in the ground equipment, in the immediate launch area, and throughout the world-wide band of tracking stations. Thus, at the moment of launch, there is assurance that everything has been checked and is in "go" condition.

After liftoff, another equally important written schedule for all events taking place during flight comes into use. Exact timing is also extremely important after the rocket is launched. While the rocket is on the launch pad, a delay may be easily called to correct a malfunction or to resynchronize systems, but after it is in flight proper time function must be automatic.

Countdown procedures differ for various kinds of space vehicles. A manned vehicle usually is ready for final checkouts about 48 hours before launch; the checkout in this case involves more complicated functions, and far more varied parts. When there is a countdown for flight to the moon—manned or unmanned—it may extend into days before launch. For unmanned research and development space vehicles, countdowns may last as long as 8 to 10 hours.

The service structure includes a series of platforms mounted one atop another on a movable structure. These platforms provide working levels so that ground crewmen may have access to all parts of the vehicle. The men working from the platform are known as the "launch operations crew," because their operations on the vehicle during this critical time greatly determine either the necessity for "holds" or the "go-ahead signal."

Probably the most critical, and the most exciting, moments of the entire countdown procedure are those of the last sixty seconds before launch. This critical last minute is announced all over the launch area. Loudspeakers and intercoms blare the magic sound "T minus 60 seconds!" It is passed on to outposts all over the world—tracking stations, communications networks, telemetry posts of all kinds. And of course it is announced on millions of radios and television sets throughout the world.

This second-by-second procedure includes many exacting processes. All motored or electrical devices necessary to the functioning of the entire vehicle system must be started. These ignitions must be accomplished in proper sequence and timing before launch. Continuous checks of fuel and oxidants are needed for quantity, temperature, and stability.

Often, especially during a manned flight, the last moments before T-time are controlled by an automatic sequencer. This is a fully automatic system which monitors in split seconds the step-by-step progression of the final countdown events. It works on the principle of perfect sequence of activities; it will stop the launch operations if an event occurs out of sequence. Automatic sequencers greatly add to the safety of launching, because they help avoid human errors and oversights during the last seconds of the countdown, when the switching sequence is rapid.

After the last 60 seconds have elapsed and the rocket is safely on its way, the countdown of plus time begins. Engine ignitions and cutoffs are timed to the second in order that the correct velocity and flight path may be maintained. Each step of the entire flight is scheduled according to the flight plans. So, the plus time countdown continues throughout the flight, and ends only when the mission is completed. This plus time is called "ground elapsed time" by space flight controllers.

QUESTIONS:

1. When does the countdown begin and end?

2. Why is it important for various stations all over the world to be alerted to the countdown procedures?

3. What is the checkoff list?

4. What is meant by hold and recycle?

5. Explain the automatic sequencer, and the reasons for its use.

ACTIVITY:

Make up a list of actions, each taking only a second or two, such as closing a book, moving a pencil from one place to another, setting an object in a certain place. First, time three short operations by a stopwatch to calculate the minimum time for each. Then make up a timetable including about a half dozen of these activities, beginning each at a particular second. Set the stopwatch for, say, 20 seconds; set each duty beside a certain second, and count down from 20 by the stopwatch. If two participate, have one count down, and have the other perform the actions as they are listed. This activity illustrates the precision with which the various actions in a countdown for launching a space vehicle must be performed.

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